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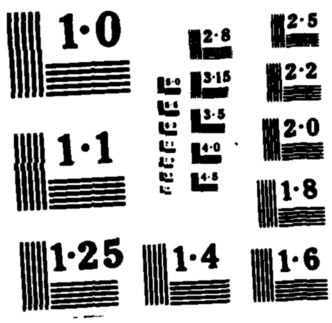
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DOWNRIGGER INSTRUMENTATION TO RECORD THERMOSONDE DATA

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This report describes the instrumentation of a package for recording of thermosonde data while suspended from a gondola of a high altitude zero pressure balloon. The data, used to determine the optical refractive index structure parameter (C_n^2) was recorded on a cassette while the package was lowered and raised. A portable console designed to control the instrumentation in the laboratory and to recover the data after the flight is also described. Keywords:

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INTRODUCTION

An experiment was proposed by the Aeronomy Laboratory of AFGL to determine the feasibility of employing a high-altitude zero-pressure balloon as a platform for temperature measurements using thermosondes.[1,2] In the experiment a thermosonde and a recorder was to be lowered and raised from the gondola to gather data away from the turbulance created by the structure. As the package decended and ascended, the temperature data was to be recorded for analysis after the recovery. The ultimate goal was to develop a package largely independent of telemetry and with minimal command link requirements to be flown as a piggyback on balloons carrying other experiments.

The thermosonde is a small, light electronic package used to measure minute temperature differences in an ambient atmosphere between two probes mounted 1 meter apart. Usually, the thermosonde is flown together with a radiosonde on a small weather balloon.[3] The rawinsonde provides MET data which, in conjunction with the thermosonde data, is used to calculate the optical refractive index structure parameter C^2_N of the atmosphere. Modified circuits of the radiosonde also provide the means to transmit the thermosonde data, together with the MET data, to the ground station for processing.[4] The thermosonde data consists of two slowly varying voltages representing the root mean square (rms) values of the temperature difference measurements. The two signals are used to extend the dynamic range of the data and differ only in their amplitudes. They are derived from the same raw signal containing spectral components up to 800 Hz. The averaging times of the rms converter circuits are in excess of one second. This signal conversion and conditioning in flight was primarily dictated by the sampling rate of the

radiosonde MET data circuits. Thus, in order to accommodate the low channel capacity of the radiosonde, the spectral information contained in the thermosonde data was lost.

In the proposed experiment only the raw thermosonde data containing the spectral components were to be recorded. The additional MET data, the ambient temperature and the pressure could be obtained from the instruments mounted in the gondola. To correlate the recovered data with the position of the thermosonde package, a simple timing code had to be included in the recording.

The electro mechanical system, including the command and the control circuits to lower and to raise the data package (the downrigger) upon a command from the ground was developed for AFGL by Tri-Con Associates.[5] The cassette tape transport, its control board and the cage to house the data package were all provided by the Aeronomy Laboratory. Only the signal conditioning circuits necessary to record and to recover the data and to control the recorder functions in the laboratory, as well as during the flight, were supplied by Electronics Research Laboratory of Northeastern University. This report describes mainly these latter signal conditioning and control circuits.

I. INSTRUMENTATION

The downrigger unit shown schematically in Figure 1 contained the recorder with its control board, the signal conditioning and control electronics, the batteries and the standard thermosonde package. These components were contained within an aluminum cage. The walls of the cage were fashioned from 2.54cm Styrofoam panels wrapped in aluminum foil.

The downrigger was designed to be energized before the launch of the balloon. The power for the electronics and the recorder during the ascent and up to the time of separation from the gondola was supplied from the battery packs in the gondola. During this portion of the flight total power dissipation in the package was approximately 5.8 watts. An additional 38 watts were available, upon demand, to heat the tape deck housing and the downrigger battery box. The tape deck was maintained at approximately 15°C. The battery box was also heated during the same time intervals as the tape deck. Power transistors were used as the heating elements. In addition to the downrigger cage walls, the battery box and the thermosonde board were protected by their own Styrofoam enclosures. The electronics were left without additional enclosures.

The heaters were supplied from a 24 volt, 7 AH nickel-cadmium battery pack, while the recorder and the electronics drew their power from +18 volt, 4 AH and -18 volt 1.2 AH battery packs.

To record the data a TRIPLE I, Inc. PHI-DECK Model 8000486 cassette tape transport and a Model 1700-100A motion and record/play control board were provided.[6,7] The two track, two channel non-reversing record/play system had a fixed speed of 4.76 centimeters/second. The usable frequency band within a +/- 3db amplitude response extended from 80 Hz to 12kHz. The recording medium was a standard good quality C-120 cassette accommodating 60 minutes of data.

The signals to execute the recorder control functions originated from the electronics of the downrigger package during the flight and from a portable control console in the laboratory and on the flight line. All of the recorder control functions: Run, Record, Stop, Fast

Forward and Rewind could be executed from the console. Only the Run, Record and the system shutdown commands were provided by the flight electronics. Whenever power was applied to the downrigger package all of the electronic circuits and the recorder were turned ON. Only the tape drive remained OFF and the bar holding the erase and the record/ playback heads was disengaged. When the downrigger package separated from the gondola, the internal batteries were switched in to provide the necessary power. At that time the run and the record commands were issued simultaneously.

The recorder control board responded to a sustained high-level record command, while the run command was latched into the control deck by a momentary logic low. To insure the acceptance of the run command, the logic low signal was repeated every two seconds for a period of 15.5 minutes. This time span was shorter than the expected record time, as required, and was easily implemented with the spare gates of the available logic IC's. When the end of the tape was detected by the recorder control board circuits, the recorder stopped and disengaged the heads. The rest of the electronics remained on. However, approximately 63.5 minutes after the separation from the gondola the battery power to the recorder and the downrigger electronics were shut off.

FM recording was used. One track of the cassette was devoted entirely to the thermosonde data. The second track carried elapsed time code, deck temperature and tape speed compensation signals. It was expected that most of the thermosonde data would be in the range from ± 50 to ± 1000 millivolts peak and only occasionally would reach a maximum of ± 3 volts in amplitude. Frequency components as high as 800 Hz could occur in the data signal. These higher frequency components were

expected to be of relatively small amplitude. The center frequency of the carrier for the data recording was chosen at 8 kHz. The carrier was deviated ±4 kHz with the maximum data signal amplitude of ±3 volts. This relatively large deviation favored the low level signals over the large amplitude data, since the upper band edge of the recording signal was limited to only slightly more than 12 kHz. This large deviation was intended to minimize the contamination of the low level data by the flutter signal of the recorder.

To compensate for the effects of the tape speed variation during the recording and the playback/demodulation process, a 10 kHz signal was recorded on the second track of the cassette. This signal was derived from a 80 kHz crystal oscillator.

The elapsed time code was also generated using that signal. The time code provided a count of the elapsed 30 second intervals from the separation of the downrigger and the gondola. One such interval of the time code is shown in Figure 2. The leading edge of the 2 second marker pulse marked the end of the previous 30 second interval. The leading edges of the 14 timing pulses following the marker were spaced 2 seconds apart. An interval of one second separated the trailing edge of the 2 second marker pulse and the leading edge of the first timing pulse. Also,a one second interval was used between the leading edges of the 14th timing pulse and the marker. A timing pulse width of one second represented a binary ONE while a 0.4 second pulse was used for a ZERO. The first timing pulse following the 2 second marker was the LSB of the binary code describing the elapsed time as the number of 30 second intervals ending at the leading edge of the marker. Thus, the arrow in the time code diagram points to an elapsed time of 125 seconds from the separation.

The time code signal keyed a carrier to 120 Hz for ONE and 0 Hz for a ZERO. This carrier, together with the 10 kHz tape speed compensation signal and the 2.8 kHz carrier used for temperature data, was recorded on track two of the cassette. The temperature data deviated the carrier approximately ± 46.875 Hz for each $\pm 10^{o}C$ change in the temperature from the center frequency representing $25^{o}C$.

The downrigger instruments were powered by two battery packs. Fifteen 1.2 AH nickel-cadmium batteries were used for the +18 volt pack. Since the downrigger required approximately 700 mA while recording data, the capacity of the battery pack was more than adequate for the duration of the experiment. The -18 volt battery was also composed of 15 nickel-cadmium batteries. It had 225 mAH capacity. The current drain from that pack was approximately 70 mA. The heaters were disabled at the separation from the gondola.

A portable, light weight console was constructed for use in the laboratory as well as on the flight line to control and to test the operation of the recorder and the downrigger electronics. The unit could be powered from a bench supply while in the laboratory environment, from the flight batteries located in the gondola on the flight line or from a +6 volt rechargeable battery within the console which powered only the control circuits.

All of the recorder functions could be accessed. Switches to simulate the separation of the downrigger package from the gondola were provided. LED indicators were included to show the status of the recorder and the downrigger electronics. A monitor was also provided for an audible confirmation that indeed the system was recording and playing back on both channels. It was thought to be a very useful

function on the flight line before the launch of the balloon.

Demodulator circuits were included in this portable unit for the recovery of the data. The demodulated thermosonde data, the time code and the temperature monitor data were available on separate outputs. Only the thermosonde data was internally compensated for the tape speed variations.

Less than 1 mV rms of noise was found to be generated by the combination of the modulator and the demodulator circuits within the pass band of the thermosonde data. In order to make this test the modulator output was connected directly to the input of the demodulator. The two circuits were adjusted and calibrated at mid-band to provide a gain of one. The gain adjustment was also checked at the two extreme deviation frequencies of 4 kHz and 12 kHz and at the center frequency using dc levels of -3V, +3V and 0V respectively to deviate the carrier. The output noise level of the modulator/demodulator combination was also measured at these three input voltages. In each case it was found to be approximately 100 uV rms. The same test was repeated by first recording the output of the modulator and then recovering the signal with the demodulator. In this test the noise signal increased to approximately 15 mV rms. This increase could largely be attributed to the flutter signal generated by the recorder.

Measurements were also conducted to determine the harmonic distortion introduced by the modulator/demodulator combination. As in the noise measurements the tape deck was bypassed and the two units were directly connected. The measurements were done at five input signal frequencies and at half scale and full scale deviation of the carrier. In each case, first the harmonic distortion of the input

signal was measured, then the distortion in the demodulated signal was determined. For these measurements Hewlett Packard Model 333A distortion analyzer was used. The results are tabulated in Table 1.

INPUT FREQ.	CARRIER DEVIATION	% DISTORTION	
		INPUT	OUTPUT
10 Hz	± 2 kHz	.4	0.6
10 Hz	± 4 kHz	.22	0.65
200 Hz	± 2 kHz	.5	0.62
200 Hz	± 4 kHz	.26	1.0
400 Hz	± 2 kHz	.2	1.2
400 Hz	± 4 kHz	.22	1.35
600 Hz	± 2 kHz	.2	0.8
600 Hz	± 4 kHz	.18	0.8
800 Hz	± 2 kHz	.2	0.45
800 Hz	± 4 kHz	.22	0.35

TABLE I. Harmonic Distortion Measurement Results

The frequency response characteristics are shown in Figure 3. This response was also measured using a direct modulator to demodulator connection. During this test the amplitude of the input signal was set at 1 Vrms. The same digital voltmeter was used to measure the amplitude of the input and the output signals at selected frequencies.

The downrigger package was subjected to a combination of vacuum and cold chamber tests at AFGL. During these tests the expected environmental flight profile, except for the heating due to the sun, was simulated. During the first test the downrigger battery package lost

approximately 30% of its expected amp-hour rating. Introduction of the previously mentioned heating transistors and the Styrofoam enclosure for the battery box corrected the problem. No deviation from the expected performance of the tape recorder and the electronics were observed during the second test conducted following the corrective measures.

II. DOWNRIGGER CIRCUITS

The circuits comprising the downrigger control and the data processing electronics are shown in Figures 5 through 7. The circuits include the modulators producing the signals to be recorded, the elapsed time code generator, the power transfer circuits to switch from the gondola to the downrigger batteries and the heaters. With the exception of the power transistors used as heater elements, the temperature sensor and one voltage regulator, all of these circuits were assembled on a single wire-wrap board.

The modulator circuits are shown in Figure 5. Voltage-to-frequency (V/F) converter IC's (U2, U4, and U5) were used to generate the carriers for the data signals. The thermosonde data was buffered by the amplifier A1 before passing into the V/F converter circuit U2.

To set the carrier center frequency, a dc offset current was derived from the voltage reference source U1. The center frequency of U2 was set at 16 kHz and could be deviated ± 8 kHz by the maximum expected thermosonde data amplitude of ± 3 volts. The frequency modulated pulse train at the output of the V/F unit was converted into a modulated square waveform of one half the original frequency by the flip-flop U3. To reduce the harmonic content of the signal before recording, the modulated square wave was first attenuated with A11 and then passed through the four pole

12 kHz low pass filter comprised of A_{1X} operational amplifiers and associated components. The resulting signal of $1V_{pp}$ amplitude was passed through a blocking capacitor to the tape deck circuits for recording on track one.

The temperature sensing IC, LM 235 (CR2) was mounted on the tape deck housing. Its nominal sensitivity was 10 mV/^{o}C. At room temperature its output voltage was near + 3V. Once again, the necessary offset voltage to achieve zero volts for 0^{o}C temperature at the output of the signal conditioning circuit (A_{31}, A_{32}) was obtained from the negative voltage output of the reference source U1. The center frequency of the V/F converter (U4) was set at 2.8 kHz by utilizing the positive reference voltage. To keep the amplitude of the output signal of the converter within acceptable limits for the following low pass filter, the output pulses were limited to +5 volts by LVA351A (CR3). The 3db frequency of the low pass filter (A_{33}, A_{34}) was set at 2.6 kHz. This selection placed most of frequency band assigned to the temperature signal on the slope of the filter frequency response curve. Thus, some additional attenuation was gained for the harmonics, without a significant loss in the amplitude of the fundamental which was expected to remain slightly below the center frequency throughout the flight.

The elapsed time code signal simply keyed the V/F converter U5 to approximately 120 Hz when the signal was high. The output of the V/F converter was near zero when the time code was at a zero level. This keyed signal was limited to +5 volt amplitude and was processed by a 100 Hz low pass filter (A_{23}, A_{24}) to remove harmonics.

The 10 kHz tape speed compensation signal was derived from a square wave originating in the time code generator. This signal was also passed

through a four pole low pass filter (A_{21}, A_{22}) to remcve the harmonics and then was mixed at A_2 with the time code and the temperature carriers for recording on track two. The amplitude of the composite signal was approximately $1V_{pp}$ as required by the recorder specifications.

The power control and the time code generating circuits are shown in Figure 6. The power control circuit was designed to switch over to the internal batteries when the power from the gondola, supplied through the pullaway, was interrupted due to the separation of the downrigger from the gondola.

To prevent damage or an accidental discharge of the internal batteries during testing, the circuit automatically switched to the pullaway connector for power when it became available. Additional protection was provided by the "arming" connector. The arming connector was also used to charge the batteries when required. At the conclusion of the experiment, the power control circuit, upon a command from the timer, disconnected the batteries from the instrumentation.

The power sources in the gondola and the downrigger were isolated from each other by a latching relay 422-18. To connect the internal battery to the instruments, not only the arming connector had to be in place, but also the power at the pullaway connection had to be available. When the power was supplied through the pullaway, the gate of Q_3 was driven beyond the threshold voltage and turned the MOSFET ON. The relay contacts assumed or remained in the position shown isolating the internal power source from the voltage regulators U6, U7 and U8. The transistor Q_1 also turned ON and kept the Q_2 unit OFF. The P-channel MOSFET Q_6, which bypassed the relay to reduce contact loading, was kept in OFF condition by Q_4. The power to U8 regulator supplying the needs of the

recorder was provided through the diode 1N5804 (CR20). The time code generator circuits were kept in the reset state by the 15 volt signal from the 1N965B zener diode, CR14.

To switch to the internal batteries, the connection to the external power sources was broken at the pullaway connector. Transistors Q_1 and Q_3 turned OFF and the capacitor C25, which was charged to nearly 18 volts, turned ON Q_2, thereby latching the relay contacts into the internal power circuits. This action could occur only if the arming connection was in place. Otherwise the relay coil in the drain circuit of Q_2 could not be energized. Once the drain of Q_3 returned to the higher voltage level, transistors Q_4 and Q_6 turned ON and supplied power to the recorder. At that time the reset signal to the time code circuits was removed, the RUN command was issued and the recording began. The record command was present whenever power to the electronics was available, but was not accepted by the recorder until the RUN command was given.

Once the reset signal was removed, the time code circuits became active. The output of the 80 kHz crystal controlled oscillator U9 was first scaled to 10 kHz squarewave which, after passing through a filter, became the tape speed compensation signal. Three other counters (U11, U12, U13) further divided the 10 kHz signal to provide signals having periods of one and two seconds. Finally, a two second pulse was generated every 30 seconds by the programmable divide by N counter U14 at pin 3. This pulse, on its negative transition advanced the count in the binary counter U16. When reset the output of U14 was high; therefore, the counter U16 was advanced to the count of ONE 2 seconds after the separation from the gondola. This count was transferred into the

parallel-to-serial converter U15 during the following marker pulse some 30 seconds later. The strobe pulse to transfer the count was generated during the marker pulse before the counter U16 was advanced to the next higher count. The output of gate 2A and the 2 second pulse from U14 produced, at the output gate of 2B, the strobe pulse which loaded the parallel-to-serial (pin 9 of U15) converter with the contents of counter U16. The contents of the parallel-to-serial converter were shifted once every 2 seconds and were inserted into to the pulse train of the time code through the logic gate arrangement. The timer waveforms at a few selected points are shown in Figure 4.

The periodic 2 second squarewave from the output of U13 (pin 3) enabled the gates 2A and 2C. Thus, the 0.4 s timing pulses from 1A and the output of the shift register U15 were passed into the OR gate 3A. The 0.4's pulse was derived by OR'ing the outputs Q_3 and Q_4 of U12 to form a 0.6 second positive pulse once every second. Then the periodic one second waveform was inverted by 1A to produce the required 0.4s pulse coinciding with the leading edge of the positive portion of the 0.5 Hz squarewave from pin 3 of U13.

When the output of the shift register (U15) was at the logical ZERO, the 0.4s timing pulse appeared at the output of the gate 3A. When a ONE was present, the one second pulse at pin 6 of 3A predominated and was passed to the gate 3B. There these timing pulses were combined with the 2 second marker pulse originating at pin 12 of U14 every 30 seconds into the time code sequence shown in Figure 2.

The RUN command was issued by turning the transistor Q_5 on. This command was repeated every two seconds for a period of approximately 15.5 minutes. At that time the output of gate 3C was set to a logical

ONE by the counter U16. The other signal to enable the AND gate 2D was supplied by pin 14 of U13 (Q_4). This gating arrangement insured that the counter in U13 was disabled in a state where pin 11 (Q_1) was at a logical ZERO thereby removing the RUN command for the duration of the flight. The recording stopped when the end of the tape was detected by the tape deck control circuits. Finally, the power to the downrigger was disconnected 63.5 minutes after the separation from the gondola. At that time pin 13 of the counter U16 switched to a ONE and through the transistor Q_3 transferred the relay (422-18) contacts to the now open pullaway connector wires.

The heater circuits are shown in Figure 7. Both, the tape deck housing and the battery box heaters were identical. The output of the single temperature sensor located on the tape deck housing controlled the power transistors Q_8 through Q_{12} serving as the heater elements. The amplifier Q_3, configured as a Schmitt Trigger, buffered the sensor from the transistors. The heater transistors were connected as current sources with the base to emitter junction of the power Darlington Q_8 developing the relatively constant voltage drop across the 3 ohm resistors. Diodes CR5-CR7 were used to develop the necessary voltage in the Q_9 circuit. In addition to its task as a heater, Q_9 also served as the power switch to control the other transistors.

III. DEMODULATOR AND CONTROL CIRCUITS

To recover the recorded data and to control the downrigger instrumentation while on the ground a portable unit was constructed. The unit contained the demodulator circuits for the four recorded signals and the circuits to control the tape recorder functions. A switch to simulate

the arming and the separation of the downrigger from the gondola was also included.

The demodulator circuits are shown in Figure 8. The sinusoid from channel 1 of the recorder carrying the thermosonde data was amplified by A_{11} and then reshaped by the comparator U2. The EXCLUSIVE-OR differentiator U3A produced positive pulses on each transition of the comparator output signal. Thus, the signal frequency was doubled and the signal was converted into a frequency modulated pulse train. The frequency-to-voltage converter U4 served as the demodulator. The inverter circuit A_{12} injected the necessary offset to obtain a zero volt output at the center frequency of the carrier. Voltage reference source U1 was used to derive the necessary offsets. The two amplifier stages (A_{13}, A_{14}) following the offset adjustment circuit served to invert the signal and to obtain the necessary gain at the data output. Thus, the offset and the gain adjustments were independent of each other. The conditioned signal was passed through the six pole filter (A_{6x}) and then combined with the tape speed compensation signal in A_{64}.

The tape speed compensation signal was derived from the 10 kHz carrier recorded together with the temperature and the time code data on track two of the tape. A 6 pole high-pass filter (A_{2x}) with a cutoff frequency at 8.9 kHz separated the signal from the other two carriers. Again a comparator was used to restore dc and to reshape the signal. The output of the frequency to voltage converter U6 was first off set and then was passed through a 6 pole, 100 Hz low-pass filter (A_{5x}) to remove harmonics and the higher frequency flutter components. The tape speed compensation signal which was combined with the thermosonde data signal and was also available as a separate output (A_{54}).

To isolate the carrier containing the temperature data a band pass filter was used. It consisted of a 4 pole, high-pass filter (A_{41}, A_{42}) with a cut-off frequency of 2.6 kHz followed by a 4 pole, low-pass circuit with a cut-off frequency of 3.1 kHz. Once again a comparator and a frequency-to-voltage converter were used to reshape and then to demodulate the recorded signal. Harmonics generated by the demodulation circuit were removed by a 4 pole, low-pass filter. The temperature data was not compensated fro the tape speed variation.

A circuit very similar to the ones described above was used to recover the elapsed time code. The differences were primarily in the use of a 4 pole, 100 Hz low-pass discriminator filter and in the coupling of the demodulated signal into the low-pass 100 Hz output filter. Since the time code carrier was either ON or OFF, there was no need to shift the dc level.

Figure 9 shows the circuits within the ground support unit used to control the functions and to monitor the operation of the tape deck and its control board. The functions that could be controlled were: RUN, STOP, RECORD, REWIND, FAST FORWARD. All except the RECORD command were activated by momentary ground closures which were latched into the deck control board circuits. The RECORD command (S_3) had to be issued as a continuous logical ONE. For that purpose a latch (U11, U12) was used with a provision for automatic RESET upon an application of power and upon the RUN command at U21. LED indicators were used to monitor the status of the recorder. The drive capabilities of the gates were augmented by the inverting and non-inverting buffers. The monitored functions are shown on the drawing and are self explanatory.

Two switches were used to simulate the flight conditions. The ARM switch simulated the arming process of the downrigger by substituting the external ± 18 volt batteries for the internal battery to drive the electronics. The second switch simulated the separation of the downrigger from the gondola by interrupting the power flow through the pull-away conncector.

In addition, a loudspeaker was connected to the audio output circuits of the tape recorder. The speaker could be switched into the track one or track two audio signals. Also, a rechargeable battery was provided to power the control and the monitor circuits on the flight line.

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V. PERSONNEL

A list of the engineers who contributed to the work reported is given below:

J. Spencer Rochefort, Professor of Electrical and Computer Engineering and Principal Investigator.

Raimundas Sukys, Senior Research Associate, Engineer.

VI. RELATED CONTRACTS AND PUBLICATIONS

F19628-74-C-0042	1 September 1973 through October 1976
F19628-76-C-0256	1 August 1976 through 31 October 1978
F19628-78-C-0218	15 September 1978 through September 1981
F19628-81-C-0162	15 September 1981 through present.

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Sukys, R. and Rochefort, J.S. "Control and Data Transmission System for a Balloon-Borne Ion Mass Spectrometer", Scientific Report No. 3. Contract AF19628-78-C-0218, October 1980, AFGL-TR-81-0202, ADA104512.

J. Spencer Rochefort, Raimundas Sukys, "Control Electronics for Airborne Quadrupole Ion Mass Spectrometer", Final Report for Contract F19628-78-C-0218, October 1981, AFGL-TR-82-0056, ADA115399.

VI. RELATED CONTRACTS AND PUBLICATIONS (cont.)

Sukys, R. and Rochefort, J.S. "GSE for Balloon Borne I.M.S.: Decommutator and D/A Units, Scientific Report No. 1 for Contract F19628-81-C-0162, October 1982, AFGL-TR-83-0095, ADA131845.

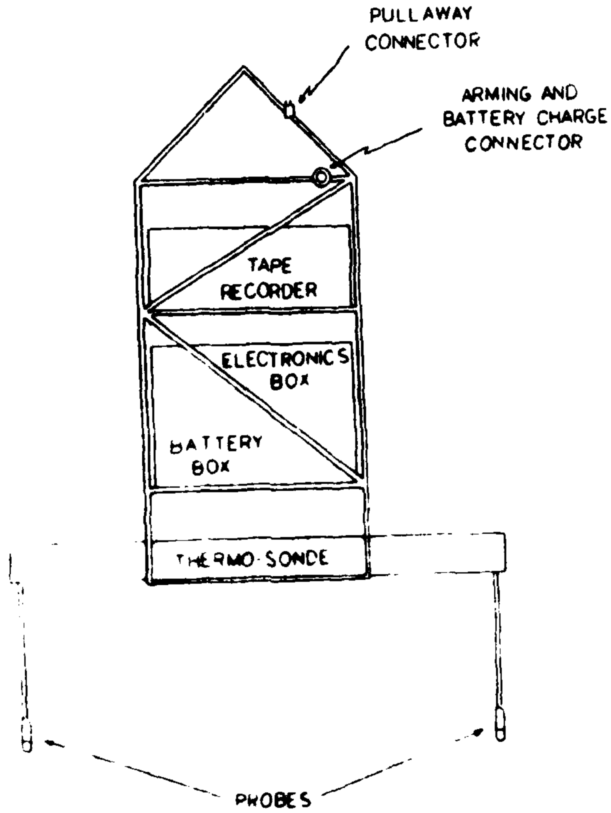


Figure 1. The Downrigger

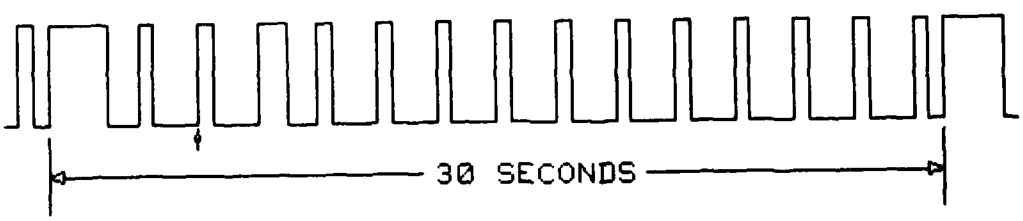


Figure 2. Time Code

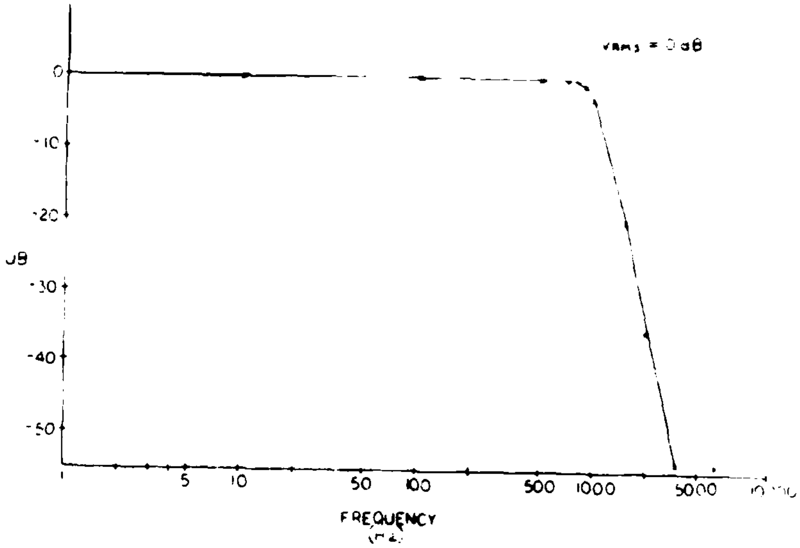


Figure 3. Frequency Response

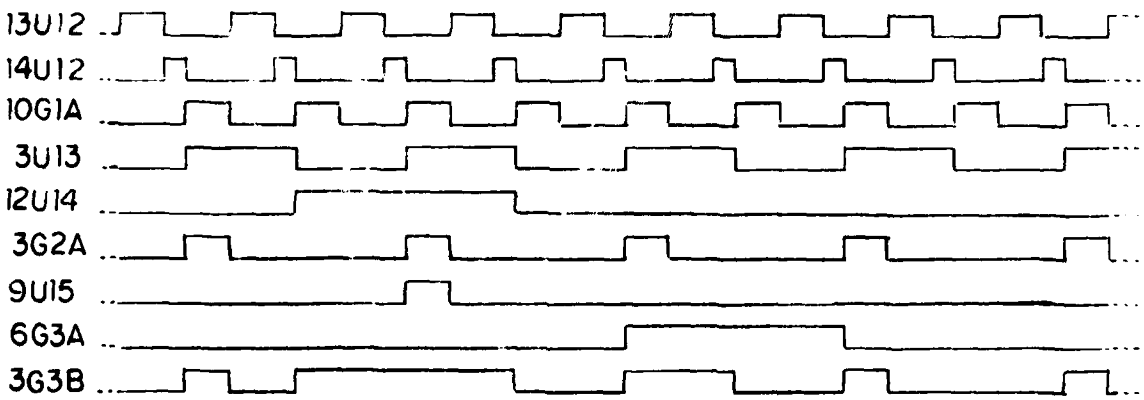
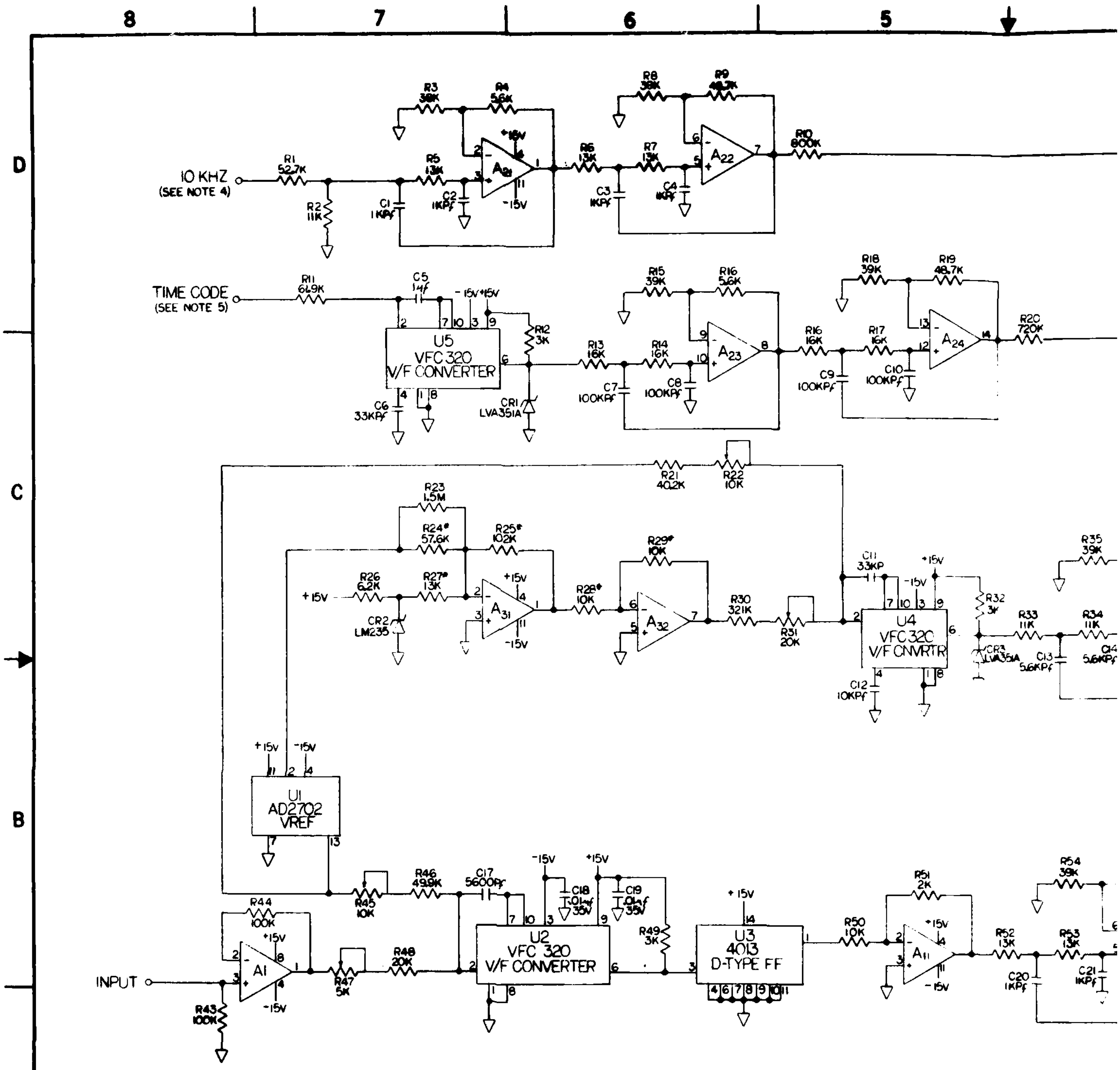


Figure 4. Timer Waveforms



NOTES:
1) * - 1% RESISTORS
2) A_{XX} - HA-4602
3) A1 AND A2 - AD647
4) CONNECTS TO 10KHZ OUTPUT ON DRAWI[NG]
5) CONNECTS TO TIME CODE OUTPUT ON D[RAWING]

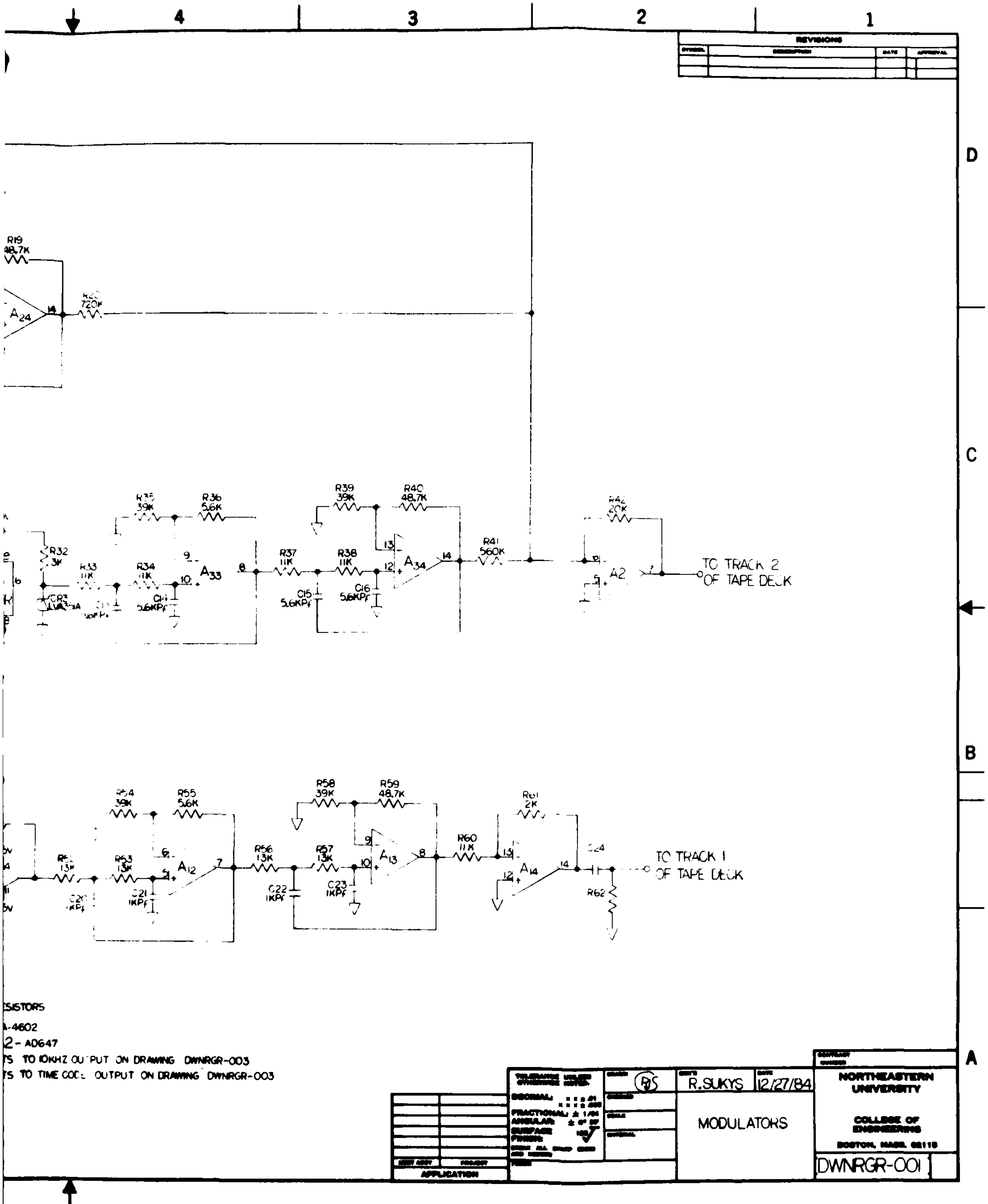
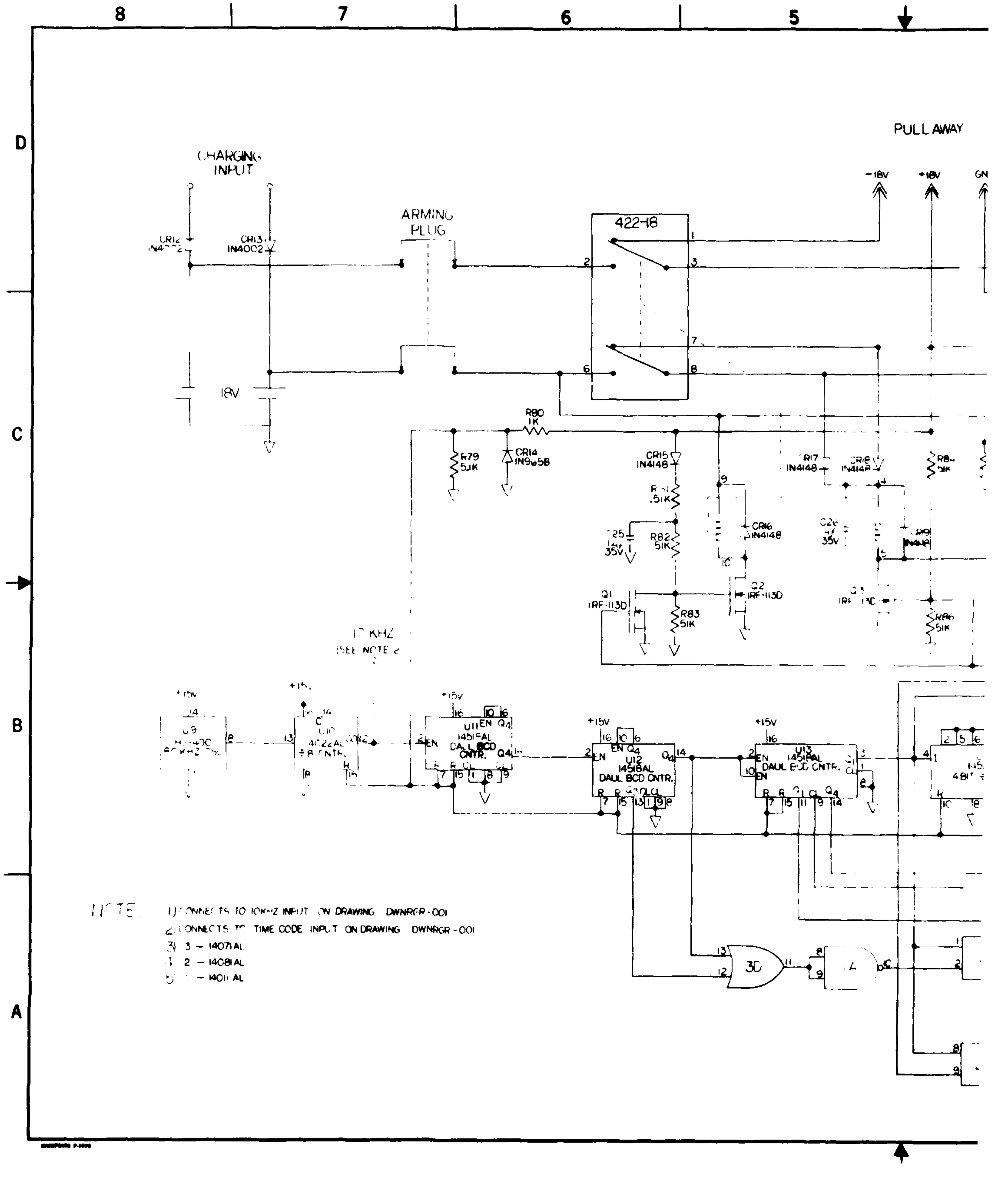


Figure 5. Modulators


8
7
6
5
D
C
B
A
PULL AWAY
-18V
+18V
CHARGING INPUT
CR12 IN4002
CR13 IN4002
ARMING PLUG
422-18
18V
R80 1K
R79 5.1K
CR14 IN9658
CR15 IN4148
R82 51K
R83 51K
CR16 IN4148
CR17 IN4148
CR18 IN4148
R86 51K
Q1 IRF-113D
Q2 IRF-113D
10 KHZ (SEE NOTE 2)
+15V
U9
U10 4022AL ÷8 CNTR.
U11 14518AL DAUL BCD CNTR.
U12 14518AL DAUL BCD CNTR.
U13 14518AL DAUL BCD CNTR.
4 BIT
3D
NOTE:
1) CONNECTS TO 10KHZ INPUT ON DRAWING DWNRGR-001
2) CONNECTS TO TIME CODE INPUT ON DRAWING DWNRGR-001
3) 3 - 14071AL
4) 2 - 14081AL
5) 1 - 14011AL

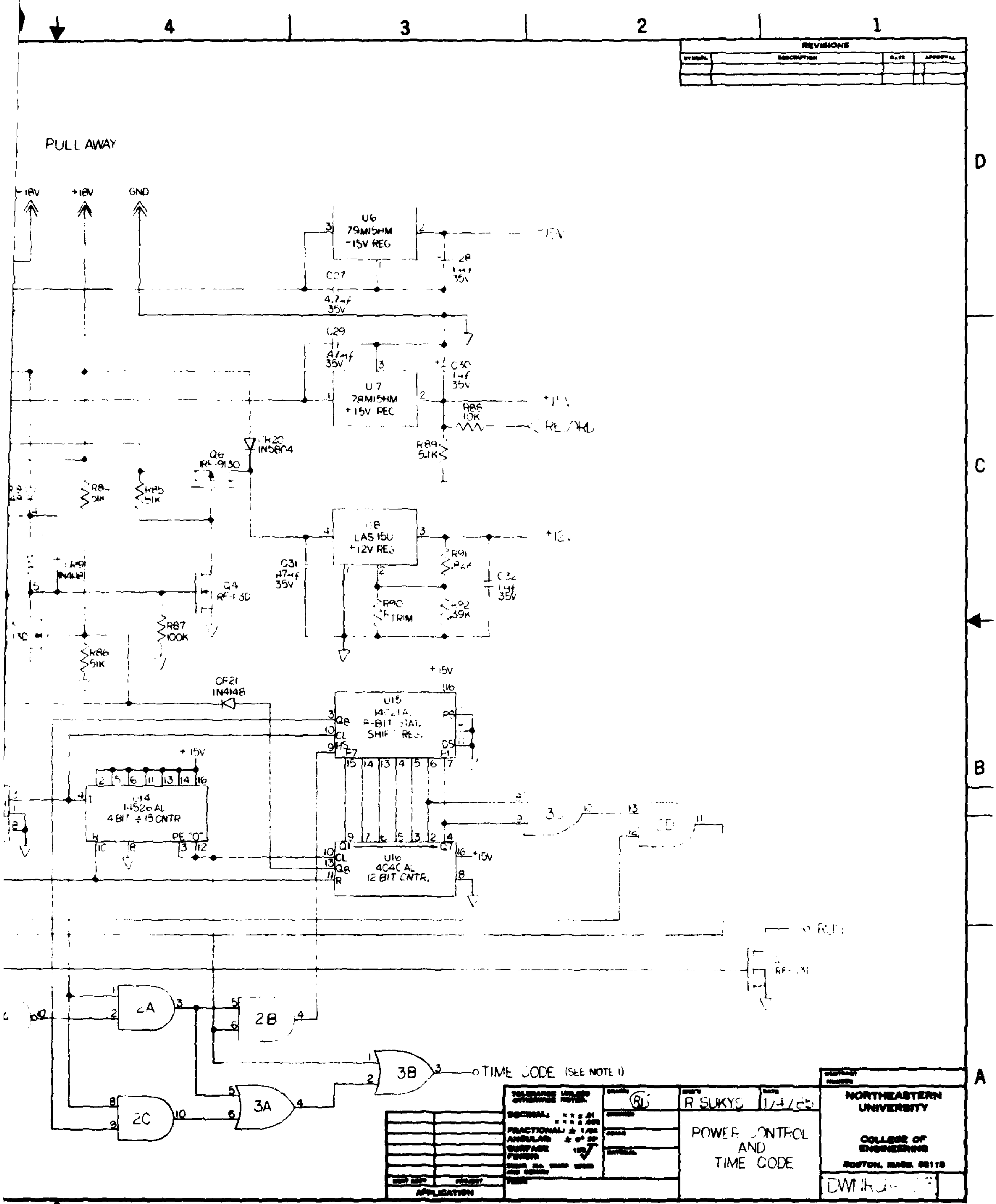
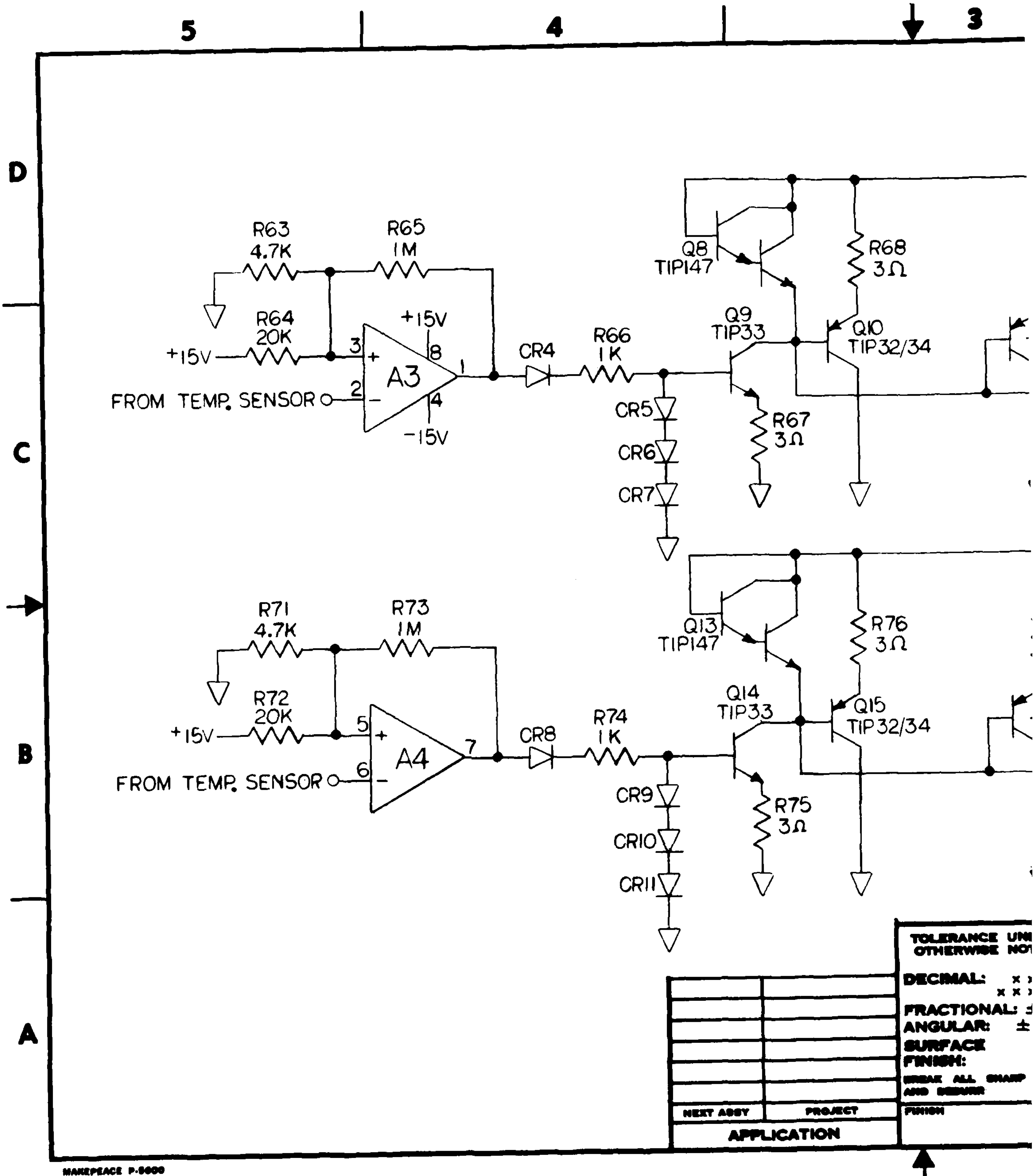


Figure 6. Power Control and Time Code Circuits

2


5
4
3
D
C
B
A
R63
4.7K
R65
1M
R64
20K
+15V
3
8
A3
1
2
4
-15V
FROM TEMP. SENSOR
CR4
R66
1K
CR5
CR6
CR7
Q8
TIP147
R68
3Ω
Q9
TIP33
Q10
TIP32/34
R67
3Ω
R71
4.7K
R73
1M
R72
20K
+15V
5
A4
7
6
FROM TEMP. SENSOR
CR8
R74
1K
CR9
CR10
CR11
Q13
TIP147
R76
3Ω
Q14
TIP33
Q15
TIP32/34
R75
3Ω
TOLERANCE UN
OTHERWISE NO
DECIMAL:
FRACTIONAL:
ANGULAR:
SURFACE
FINISH:
BREAK ALL SHARP
AND DEBURR
FINISH
NEXT ASSY
PROJECT
APPLICATION
MAKEPEACE P-5000

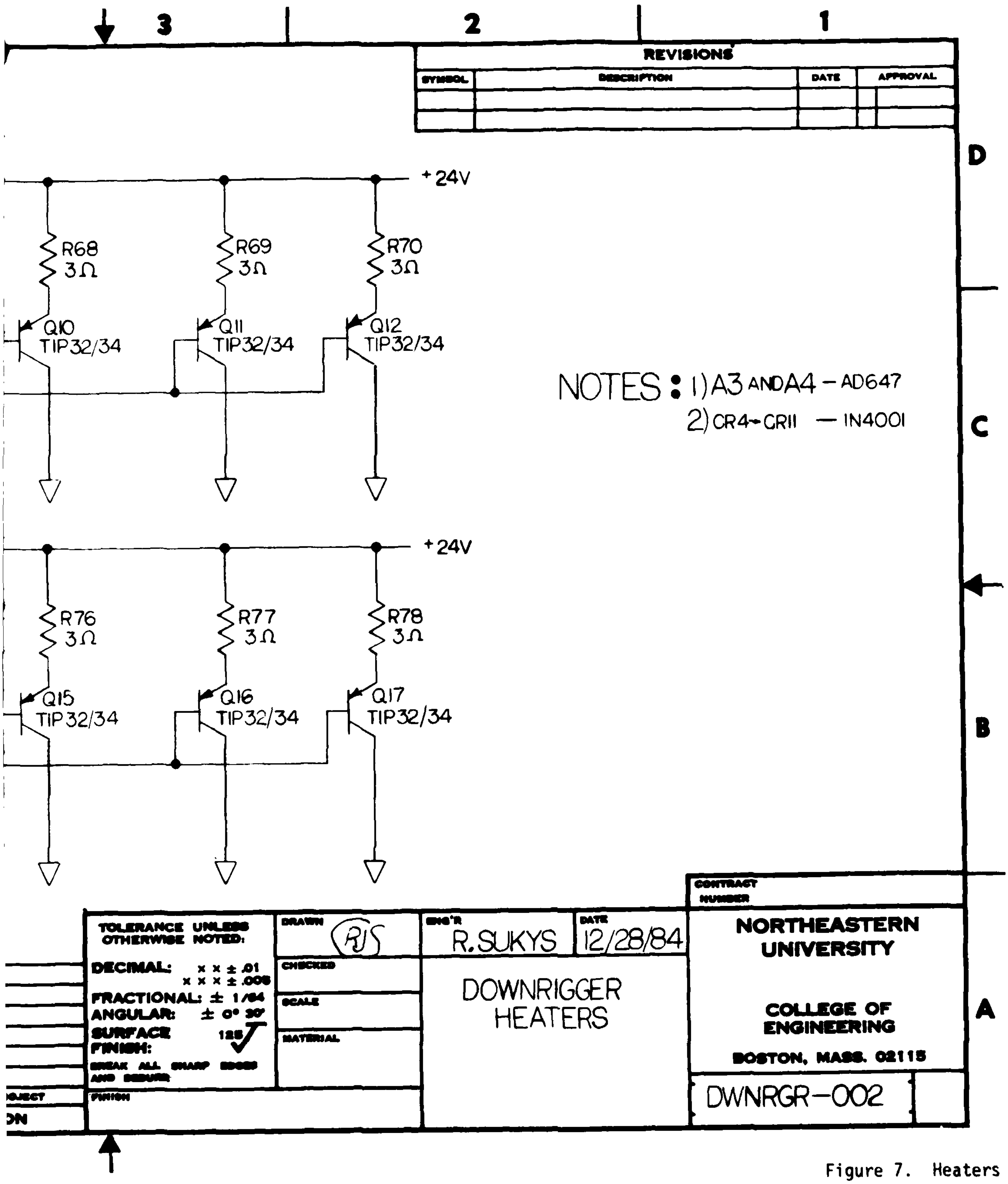
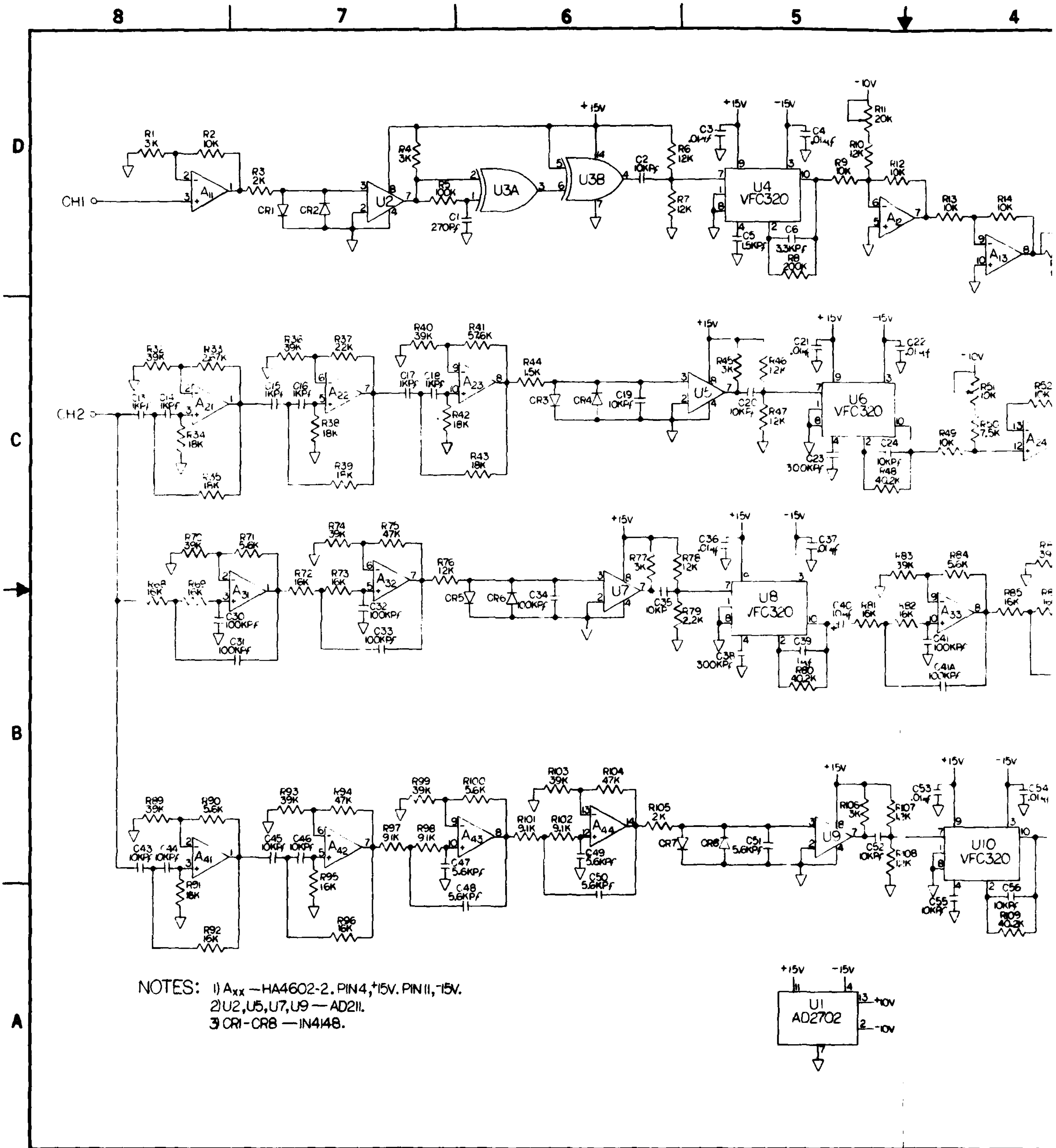


Figure 7. Heaters

2



NOTES: 1) A_{xx} — HA4602-2. PIN 4, +15V. PIN 11, −15V.
2) U2, U5, U7, U9 — AD211.
3) CR1-CR8 — 1N4148.

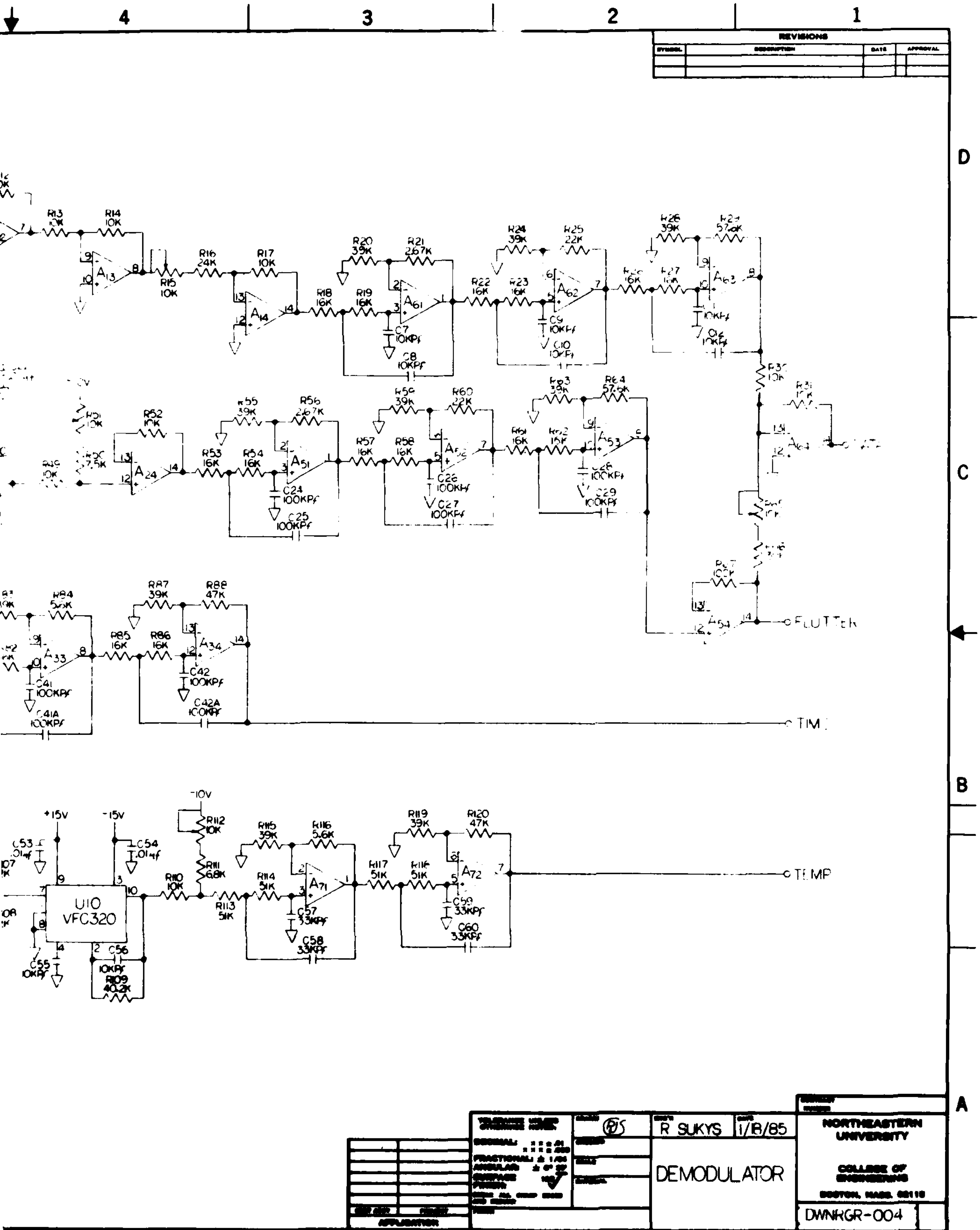
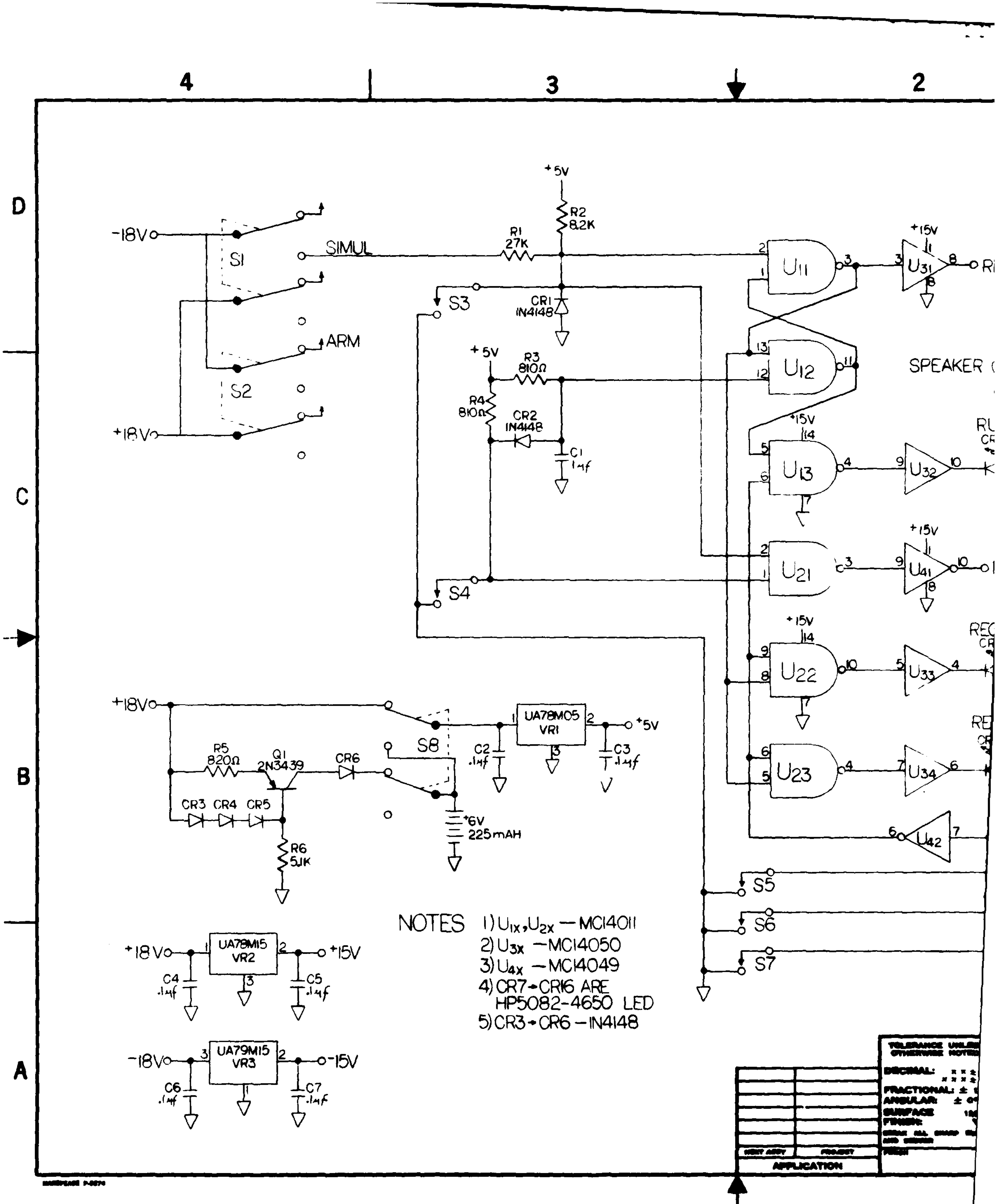


Figure 8. Demodulators

2


4
3
2
D
C
B
A
-18V
+18V
S1
S2
SIMUL
ARM
+5V
R2
8.2K
R1
27K
S3
CR1
IN4148
+5V
R3
810Ω
R4
810Ω
CR2
IN4148
C1
.1μf
S4
U11
U12
U13
U21
U22
U23
U31
U32
U33
U34
U41
U42
+15V
SPEAKER
S5
S6
S7
+18V
R5
820Ω
Q1
2N3439
CR3 CR4 CR5
CR6
R6
5.1K
S8
UA78M05
VR1
C2
.1μf
C3
.1μf
+5V
+6V
225mAH
UA78M15
VR2
C4
.1μf
C5
.1μf
+15V
UA79M15
VR3
-15V
C6
.1μf
C7
.1μf
NOTES
1) U1x, U2x — MC14011
2) U3x — MC14050
3) U4x — MC14049
4) CR7→CR16 ARE HP5082-4650 LED
5) CR3→CR6 — IN4148
APPLICATION

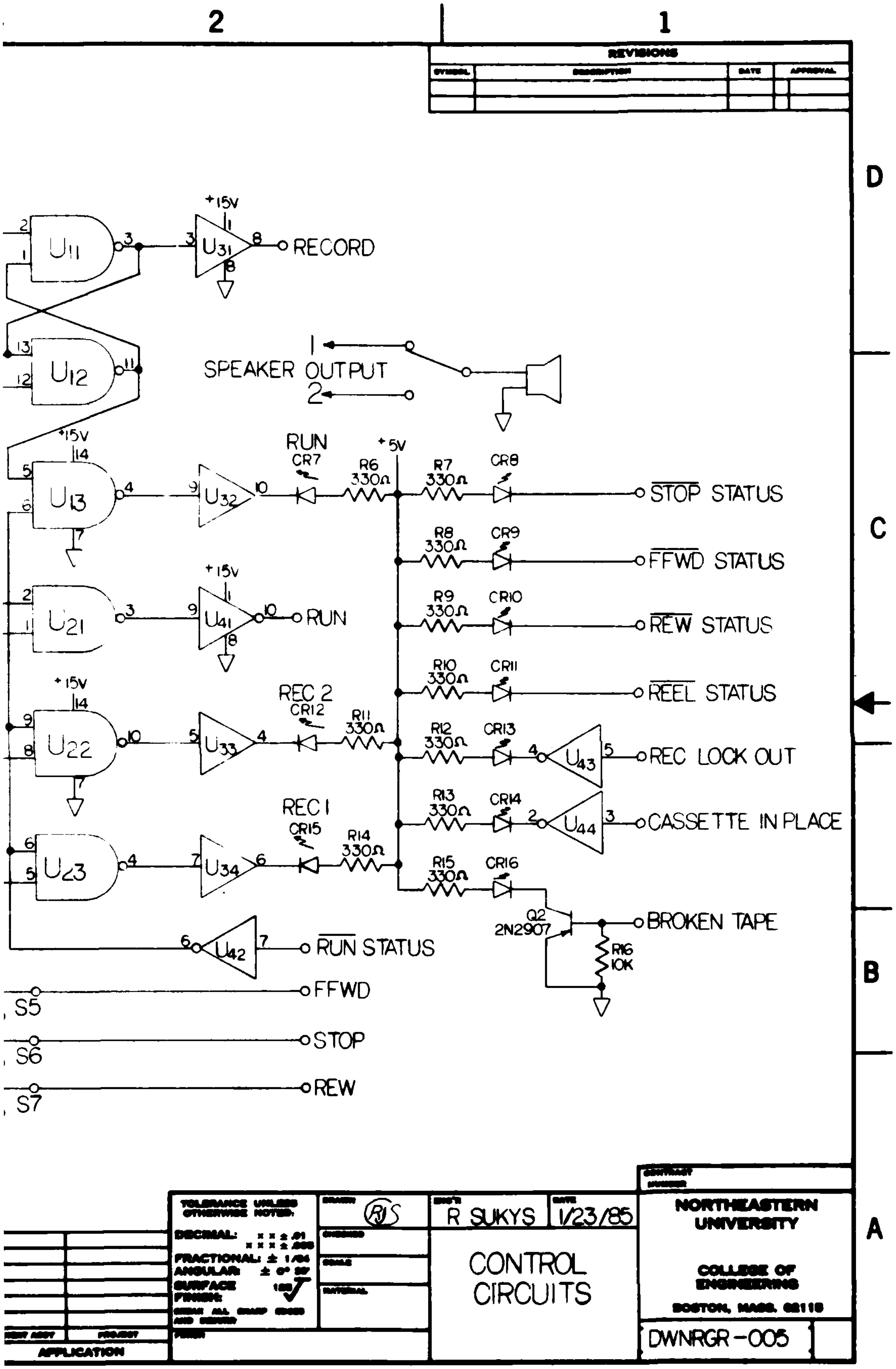


Figure 9. Control Circuits

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